AD-A146 196

AD______________ (12)

REPORT NO. T4/84

20030109008

SMALL ANIMAL HYPOBARIC CHAMBER

US ARMY RESEARCH INSTITUTE OF ENVIRONMENTAL MEDICINE

Natick, Massachusetts

SEPTEMBER 1984

Approved for public release; distribution unlimited.

UNITED STATES ARMY
MEDICAL RESEARCH & DEVELOPMENT COMMAND

84 09 26 120

The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

DISPOSITION INSTRUCTIONS

Destroy this report when no longer needed.

Do not return to the originator.

unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER

2. GOVT ACCESSION NO. AD-A146196

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)

Small Animal Hypobaric Chamber

5. TYPE OF REPORT & PERIOD COVERED

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)

James A. Devine

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS

US Army Rsch Institute of Environmental Medicine
Natick, MA 01760

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

3M161102BS10
44682101002

11. CONTROLLING OFFICE NAME AND ADDRESS

Same as 9

12. REPORT DATE

22 May 84

13. NUMBER OF PAGES

10

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

15. SECURITY CLASS. (of this report)

unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution is unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

hypobaric chamber, atmospheric pressure simulation, environmental control, small animal research

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Small Animal Hypobaric Chamber is a special test facility designed and constructed to fill a void that existed for a high-quality, scientific tool providing controlled atmospheric pressure and environmental conditions for studies and experiments which previously could be carried out only on a restricted basis in the laboratory under less-than-ideal conditions. The test facility provides a means for studying laboratory animals under low barometric pressures duplicating those found in mountainous terrain. The basic objectives
(over)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

of the Small Animal Chamber are to extend research capabilities for evaluating the effects of environmental extremes and to develop models for studying the altitude-induced effects on biological systems.

FOREWORD

Citations of commercial organizations and trade names in this report do not constitute an official Department of the Army endorsement or approval of the products or services of these organizations.

TABLE OF CONTENTS

LIST OF FIGURES

ABSTRACT

The Small Animal Hypobaric Chamber is a special test facility designed and constructed to fill a void that existed for a high-quality, scientific tool providing controlled atmospheric pressure and environmental conditions for studies and experiments which previously could be carried out only on a restricted basis in the laboratory under less-than-ideal conditions. The test facility provides a means for studying laboratory animals under low barometric pressures duplicating those found in mountainous terrain. The basic objectives of the Small Animal Chamber are to extend research capabilities for evaluating the effects of environmental extremes and to develop models for studying the altitude-induced effects on biological systems.

DESCRIPTION:

The Small Animal Hypobaric Chamber (SAHC) is a special test facility designed and constructed to fill a void that existed for a high-quality, scientific tool providing controlled atmospheric pressure and environmental conditions for studies and experiments which previously could be carried out only on a restricted basis in the laboratory under less-than-ideal conditions (Fig. 1).

The test facility provides a means for studying small laboratory animals under conditions of low barometric pressures duplicating conditions found in high mountainous terrain. Combined pressure temperature environmental chambers have been designed for use in studying materials, hardware and humans for application to other military or space missions. The basic objectives of the SAHC are to extend research capabilities for evaluating the effects of environmental extremes on laboratory animals and to develop models for studying the altitude-induced effects on biological systems. A duplicate chamber facility allows for concurrent normobaric experiments.

BASIC DESIGN:

The SAHC is a rectangular shaped vessel, primarily constructed of aluminum plate and cast acrylic Plexiglas®. It measures 36" x 28" x 20" with an internal volume of 11.4 cubic feet. The skeletal structure is a framework of aluminum angle 1/4" x 2" x 2" that is designed to support loads imposed by the differential pressure of test altitudes up to 40,000 ft (28 tons). The

end caps and base are cut from 1/4" aluminum plate and reinforced with transversed structures (stiffeners) that divide the unsupported areas into smaller configurations for maintaining the metal integrity when under differential pressure stresses (Fig. 2). Several 1/4" NPT holes are provided in each end cap for attachment of control equipment and instrumentation. The sides and top are 1" Plexiglas® providing maximal visual surveillance of inside activities without compromising basic requirements of selecting material with high strength to weight ratio. Plexiglas® is tailor-made for this type of small vacuum vessel because of its outstanding memory and flexure characteristics. Each side is bolted to the frame through a 1/8" x 2" rubber gasket using 52 stainless steel nuts and bolts (Fig. 3). They are designed for easy removal in the event maintenance or repairs become necessary. The gasket material is 40 durometer hardness, silicone-impregnated rubber and is cut from sheeting as one piece (seamless). Access to the chamber interior for experimental set-up and cleaning is provided by a removable top. Quick release cam-lock type clamps are used for securing the top to the chamber. The clamps are strategically placed to apply an even distribution of compression on the rubber gasket and facilitate the initial vacuum application. A plenum housing which contains a heat exchange coil is located externally to the aluminum end cap of the chamber (Fig. 3) and has a miniature air circulating fan and an air channeling baffle plate for smoothing and concentrating the flow of air through the coil.

CONTROL INSTRUMENTATION:

(a) Altitude Simulation: Chamber pressure is automatically controlled (Fig. 4) using a Hewlett Packard computer (Model 16) and a Hewlett Packard Data Acquisition/Control Unit (Model 3497A, DACU). The DACU digitizes an analog voltage (0-5 VDC) derived from a digital pressure gauge (Mensor, Model 6240). The computer then uses the digitized signal in a feedback loop software program to control an incremental solenoid valve on a Porter Thermal Mass Flowmeter (F-2-2MFC). A Gast Vacuum Pump (Model 1022) is used to reduce pressure in the chamber compartment.

(b) Ventilation Air: Acceptable levels of oxygen and carbon dioxide gases are maintained by purging the chamber with sufficient volumes of fresh air. Incorporated in the software program are additional feedback signals in which chamber oxygen and carbon dioxide concentrations are compared to reference values and appropriate adjustments made by a second mass flow controller to the purge ventilation line. Beckman Medical Gas Analyzers (Model OM-14, oxygen, LB-2, carbon dioxide)are used to measure gas concentrations.

(c) Temperature Control System: Temperature control (0-100° C) is effected by using a remote-controlled circulating bath (Lauda, Model KTC-4). Constant temperature control capabilities are provided by built-in mechanical refrigeration and heating units. A remote thermistor is mounted inside the chamber allowing the interior to be the control point. Fluid (glycol/water) is circulated through the chamber's heat exchange coil (Eastern Industries,

Model E/HT 200) and returned to the circulating bath. Concurrently, air is circulated around the fins of the coil transferring fluid temperature into the chamber interior. A ceramic enclosed platinum resistance sensor element is used to measure the temperature. The sensor is housed in a environmentally-rated anodized aluminum collar (pressure boss) for pressure/vacuum applications. The pressure boss enables the sensor to be installed in the vacuum pump exhaust line, where air being drawn from the chamber circulates around the sensor providing the measurement. Temperature and relative humidity data are displayed on a digital readout instrument (General Eastern, Model 400E) with analog outputs (0-5 VDC) available for recording.

(d) Relative Humidity Control System: Relative humidity is controlled by employing a unique environmental engineering approach. The basic concept employs the chamber's ventilation air as a means for injecting pre-conditioned air. Humidification is accomplished by passing ventilation air through a water jacketed-aerator. The amount of saturation is controlled by modulating an ambient air bypass line to mix with the humidified line until desired set-points are reached. Dehumidification is accomplished by passing ventilation air through a condenser (Allihn, Model C7930) where moisture collects on the inner surface of the cooled tube with water droplets collecting in a condensate container below. The condenser is cooled using a vortex tube (vortex Corp., Model 208) that converts ordinary compressed air (60-80 psi) into a cold stream of air (-40°F). The amount of water being removed from the ventilation air stream is proportional to temperature of cold air supplied to the condenser from the vortex tube. Lowering air pressure has the effect of warming the vortex temperature and vice versa. Humidity is measured using

sulfonated polystyrene resistance (AC) grid housed in a pressure boss. Both processes, (humidification/dehumidification), are balanced with ambient air for achieving desired relative humidity within the chamber.

CONCLUSION:

A hypobaric test facility devoted to small animal research represents a significant achievement in the science of environmental medicine and a forward step in the engineering science of combined environmental simulation in small research chambers. The applicability of the SAHC extends beyond the Department of Defense to universities and institutions where a growing number of scientific personnel share an interest in extending knowledge of medical and biomedical effects of hypobaric environmental extremes.

ACKNOWLEDGMENT

The author wishes to thank Mr. Jose Miletti for technical assistance on the instrumentation interface, draftsman SP4 William Sawyer for the mechanical drawings, Dr. Allen Cymerman for editorial review, and Mrs. Ruth Saleson for preparing the document.

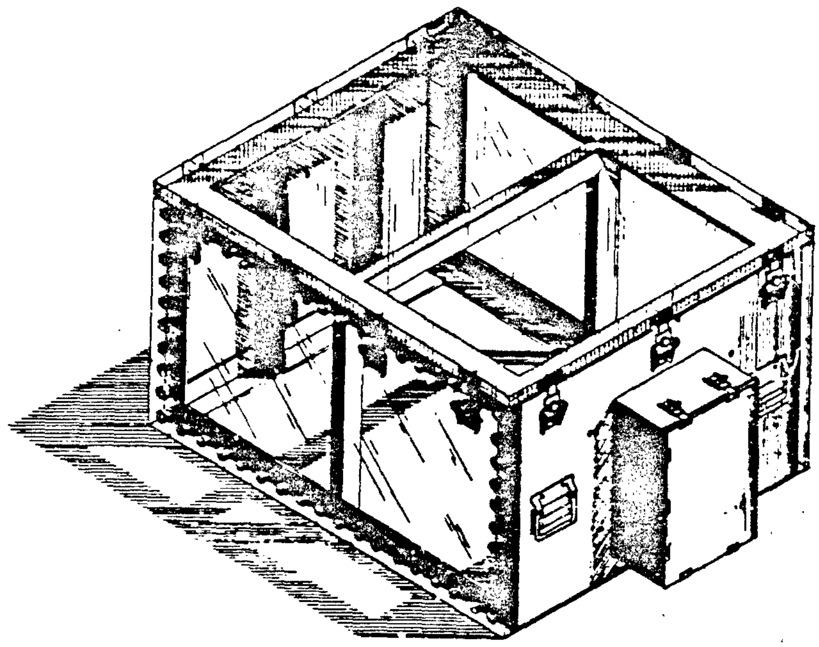

Fig. 1. Isometric view of the Small Animal Chamber showing the basic design structure: aluminum plate base and end caps, aluminum angle skeletal frame, cast acrylic Plexiglas® top and sides, and the plenum chamber on the right side of the end cap which houses the heat exchange coil.

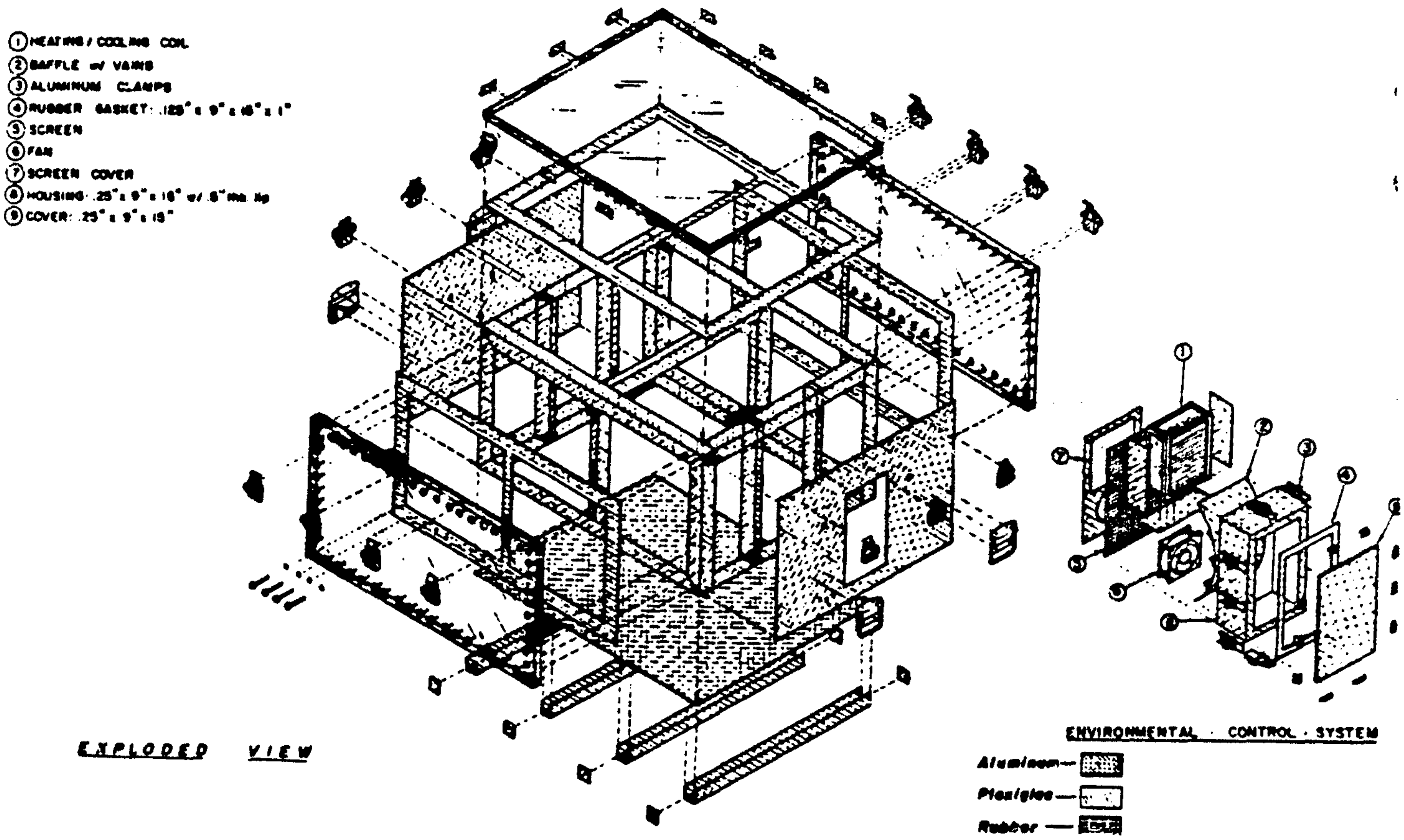

Fig. 2. Exploded view of the Small Animal Hypobaric Chamber showing the individual parts of the facility and indicating their proper relationship to the unit when assembled. Also included are the dimensional data for the heating/cooling coil.

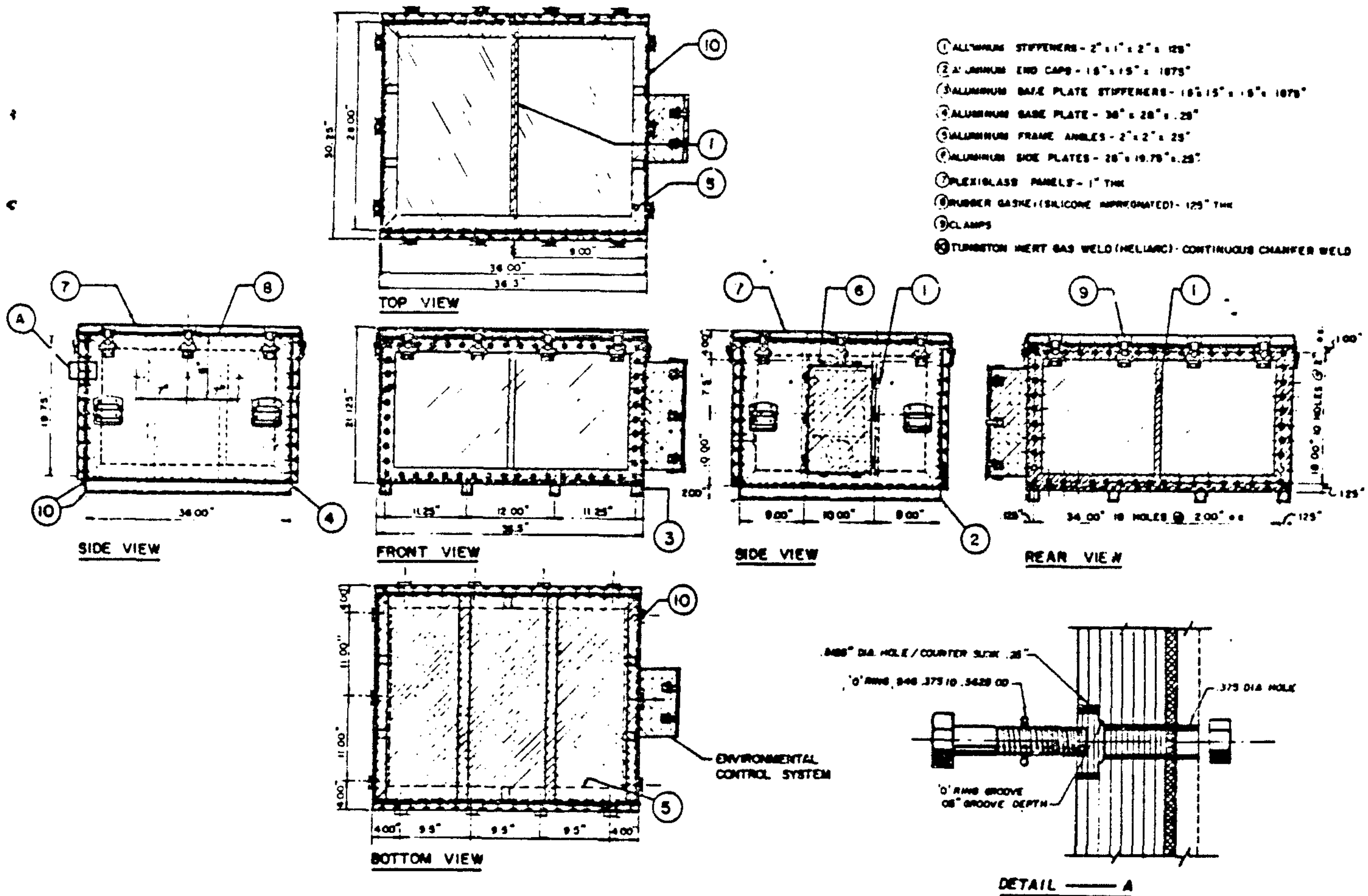

Fig. 3. Specific views of assembly along with dimensional and engineering data. Detail A shows the installation of the bolts used to retain Plexiglas® sides to the frame.

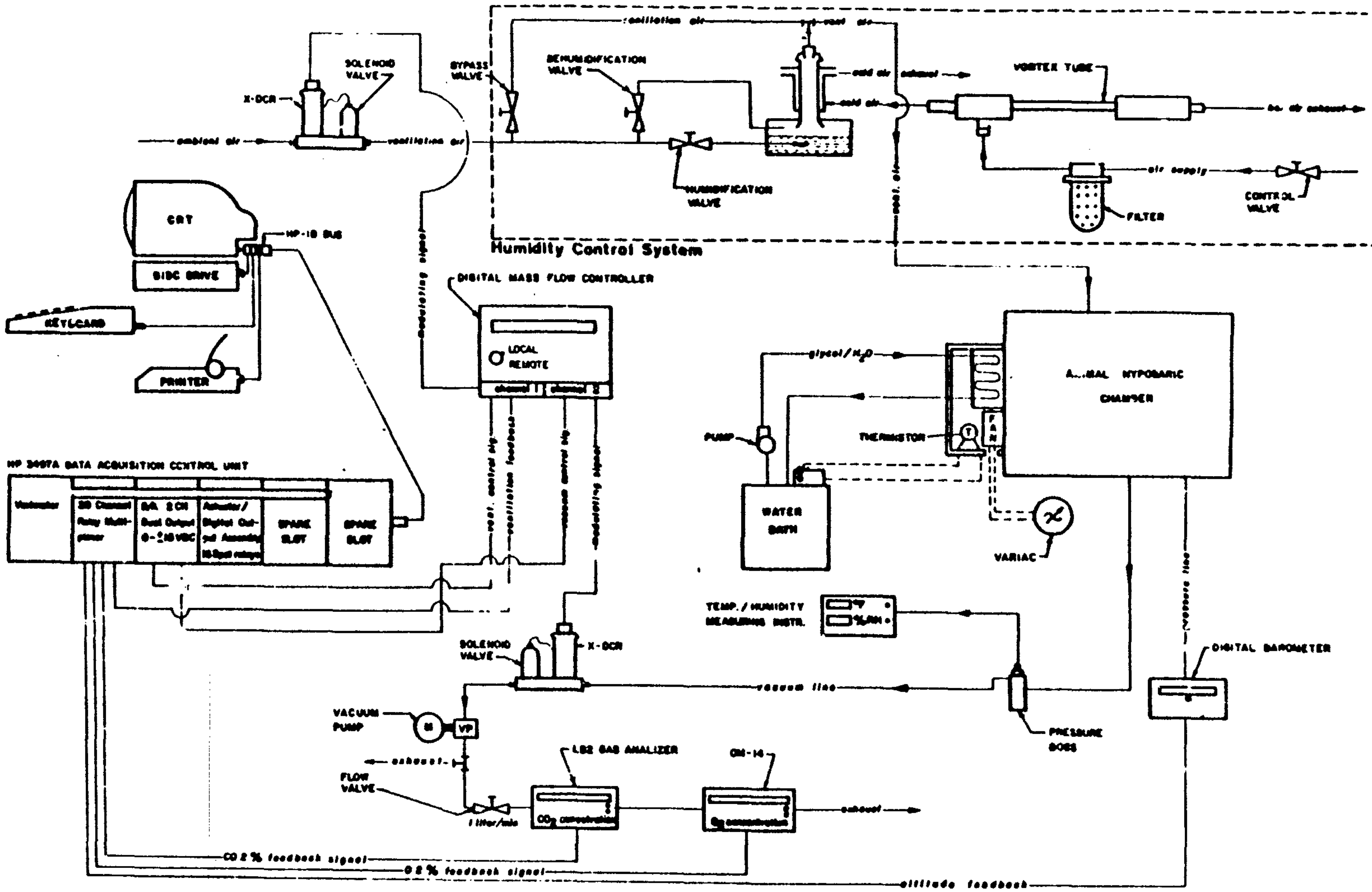

Fig. 4. Schematic showing the computerized data acquisition and control instrumentation used to create the environmental simulation of the Small Animal Hypobaric Chamber.

DISTRIBUTION LIST

2 copies to:

Commander
US Army Medical Research and Development Command
SGRD-RMS
Fort Detrick
Frederick, MD 21701

12 copies to:

Defense Technical Information Center
ATTN: DTIC-DDA
Alexandria, VA 22314

1 copy to:

Commandant
Academy of Health Sciences, US Army
ATTN: AHS-COM
Fort Sam Houston, TX 78234

1 copy to:

Dir of Biol & Med Sciences Division
Office of Naval Research
800 N. Quincy Street
Arlington, VA 22217

1 copy to:

CO, Naval Medical R&D Command
National Naval Medical Center
Bethesda, MD 20014

1 copy to:

HQ AFMSC/SGPA
Brooks AFB, TX 78235

1 copy to:

Director of Defense Research and Engineering
ATTN: Assistant Director (Environmental and Life Sciences)
Washington, DC 20301